Scientific Research Publishing

Journal of High Energy Physics, Gravitation and Cosmology, 2025, 11(3), 889-913
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

Bell's Inequality and Quantum Gravity: On the Incompleteness of Quantum Mechanics and General Relativity

Xinzhong Wu

School of History and Culture of Science, Shanghai Jiao Tong University, Shanghai, China
Email: sju@sina.com, wuxinzh@sjtu.edu.cn

How to cite this paper: Wu, X.Z. (2025) Bell's Inequality and Quantum Gravity: On the Incompleteness of Quantum Mechanics and General Relativity. *Journal of High Energy Physics, Gravitation and Cosmology*, **11**, 889-913.
https://doi.org/10.4236/jhepgc.2025.113057

Received: March 31, 2025
Accepted: July 13, 2025
Published: July 16, 2025

Abstract

This paper examines the history of Bell's inequality from EPR argument to Bell's papers, and the influence of Bell's inequality on the frontier exploration of quantum mechanics. It is found that Bell's inequality has some hidden assumptions that are different from EPR argument. Along Schrodinger's idea that the measurement process of the EPR experiment requires time, Karl Hess and his follows treat time as a time order parameter, by extending the method of space-time geometry analysis of relativity to the localized geometry analysis of quantum states, it is believed that the reasoning of Bell's inequality does not meet the requirements of the completeness of EPR argument. Analyzing the non locality of gravitational energy in general relativity makes it necessary for us to seek a more localized expression of relativistic gravitational theory. Based on local realism, exploring new interpretations and expressions of quantum mechanics may open up new avenues for studying quantum gravity. We found that Lorentz almost discovered the incompleteness of general relativity but erroneously insisted on the concepts of ether and absolute space, just as Einstein correctly discovered the flaws in the non local representation of quantum mechanics based on outdated determinism.

Keywords

EPR Argument, Bell's Inequality, Quantum Gravity

1. From EPR Paradox to Bell's Inequality

In 1935, Einstein, Podolski, and Rosen published a paper in the 47th issue of the Physical Review, proposing the principle of local realism and attempting to prove that quantum mechanics is incomplete to describe microscopic systems. The "physical reality standard" of the "complete physical theory" proposed in the EPR paper is that any observable quantity of a system should have an objectively determined value without interference. The "locality criterion" is that if the 4-dimensional spacetime interval between two measurements is space-like, then there will be no causal relationship between the two measurement events [1]. Based on these two principles, we can conclude that if the two measurements of the observables of A and B are separated by a space-like interval, then the measurement of A must not affect the measurement of B, and vice versa, the measurement of B will not affect the measurement of A (under a space-like interval separation) [1].

Niels Bohr soon published a paper of the same name in the 48th issue of the Physical Review, refuting the EPR argument. Bohr rejected the epistemological criteria proposed by three scholars on the basis that the observed microscopic system, together with the observation instrument, constitutes a single, indivisible system at the level of quantum mechanics. Bohr believed that in EPR experiments, determining the position of one system can infer the position of the other system. But when determining the position of the previous system, there is uncontrollable uncertainty in the momentum of this system, and we cannot infer the exact momentum of the next system based on the law of conservation of momentum like Einstein did ([2], pp. 270-272).

On August 14, 1935, Schrödinger submitted a paper to the Cambridge Philosophical Society that was contrary in many ways to Bohr's discussion of the EPR thesis, involving the famous "Schrödinger Cat" experiment and the so-called "quantum entanglement". He reconfirmed and extended the results of the EPR paper as a sign of serious flaws in quantum mechanics ([2], pp. 293-294). In Schrödinger's view, quantum measurements require time rather than instantaneous action, which makes the assumption of simultaneity of measurement results implicit in EPR arguments problematic ([2], p. 299).

David Bohm proposed the experiment of positive and negative electron pairs with a total spin of ħ/2 as a replica of the EPR experiment in 1951. When a pair of electrons fly in opposite directions, constantly increasing their spatial distance from each other, and the moments when they are independently measured are close enough, then these two measurement events are in a quasi spatial separation. According to the local causality law, measuring electron A will not have any impact on positron B ([3], p. 255).

John Bell derived the famous Bell inequality from Einstein's theory of local reality and the existence of hidden variables in 1964, stating that all the local hidden variable theory's predictions conform to this inequality, while some quantum mechanics" predictions may violate this inequality. The Bohm theory, which is equivalent to quantum mechanics in empirical prediction, belongs to the theory of non local hidden variables and can also break Bell's inequality.

Bell uses λ to define an implicit variable. The symbol λ represents Einstein's real elements, leading to controversial measurement output issues. The random variables A, B, and C in the Bohm electron spin experiment are represented by Bell's labeling functions $A(a, \lambda)$, $A(b, \lambda)$, and $A(c, \lambda)$, which can be assumed to have values of +1 or −1. For any implicit local variable theory, the following Bell inequality should be satisfied between the three sets of experimental statistical averages:

$$A(a,\lambda)A(b,\lambda)+A(a,\lambda)A(c,\lambda)-A(b,\lambda)A(c,\lambda)\le +1 \quad (1)$$

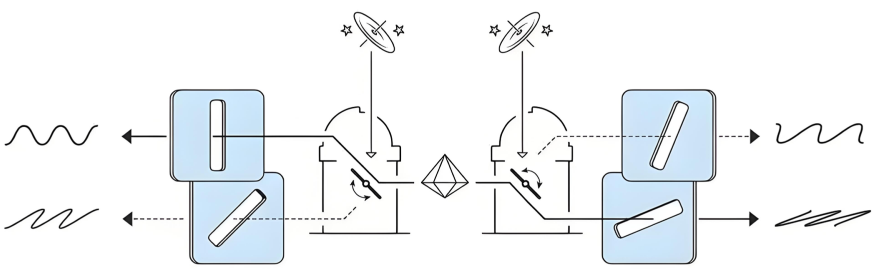
Based on a series of experimental results, Zhang Yongde points out that: 1) the completeness of quantum mechanics and the existence of hidden variables are still uncertain; 2) All experiments clearly support the quantum superposition states, the randomness and non locality caused by entanglement and measurement ([3], pp. 259-260). In Zhang Yongde's view, "*both non relativistic quantum mechanics and relativistic quantum field theory are spatial non local theories under the guise of local descriptions*" ([3], p. 265).

After a plenty of falsified experiments on Bell's inequality, various hypotheses, theories, and models of quantum gravity were mostly forced to accept the non locality of quantum mechanics that conflict with the spirit of relativity. Roger Penrose described the EPR type spin photon experiment as follows: "*The part of* '*information*' (*i.e. different polarization directions*) *reaches faster than light* ('*instant*'), *and the knowledge of which of these two directions is actually polarized will arrive slower by transmitting the usual signal of the first polarization measurement. In the usual sense of sending information, although the EPR type experiment does not conflict with the causality of relativity, it certainly contradicts the relativistic spirit of our physical reality* '*image*'." [4] Penrose linked quantum non locality with the spatial dispersion of individual particles, the superposition of quantum states, wave packet collapse, and the non locality of gravitational self energy, the superposition of quantum states is related to the superposition of different spacetime metrics. The vacuum fluctuations of the quantum field show EPR correlations in the region of space-like separation [5].

2. Why Is Bell's Inequality Wrong?

When most scholars like H When Fritsch announced in his popular science dialogue, "*You're wrong, Mr. Einstein*!" [6], there were still a few physicists who bravely followed Einstein's explanation of quantum mechanics, exposing various errors in Bell's inequality argument. Famous physicists who issued statements opposing instantaneous effects include Murry Gell-Mann and M O. Scully, Y. Aharonov, B. G. Englert *et al.* [7]. Gell Mann pointed out in "*Quarks and Puma*" that "*the false reports of one photon immediately affecting another have led to all kinds of regrettable conclusions. Firstly, the assertion that the effect is instantaneous violates the requirements of relativity… Secondly, some authors claim that the phenomenon of* '*superluminal*' *can be accepted in quantum mechanics, such as precognition, that some* '*psychics*' *can know in advance the results of some accidental processes. Needless to say, these effects will disrupt quantum mechanics, just as it has disrupted classical physics… The third form of foolishness is to succumb to certain suggestions, such as the US Department of Defense*'*s proposal to use quantum mechanics to achieve military communication at superluminal speeds.*" [8].

In 1988, when discussing the test of Bell's inequality in "*Human Philosophy*", Jin Guantao mentioned that the Copenhagen interpretation excludes telepathic superluminal signals by sacrificing the objectivity of microscopic objects, and some even extended the conclusion that the moon does not exist when no one is watching, materialism has been proven false today. But if we acknowledge signals that exceed the speed of light, it is equivalent to believing in telepathy, shaking the foundation of the entire science, especially the theory of relativity, which will be overturned ([9], pp. 14-15). Jin Guantao attempted to revise the traditional concept of objective reality by introducing constructivism, and proposed that a set of experimental instruments based on natural law constraints have artificially set overall correlations, which can be used to understand the seemingly existing quantum non locality in Bell type experiments as shown in **Figure 1**. He believes that in a series of spin correlation experiments, "*there is no such thing as superluminal transmission of signals. Due to the isomorphism between natural laws and instrument relationships, when one observer can foresee the observation of another observer based on a certain natural law, it actually means that the other observer can only measure the corresponding observable quantity by adjusting the instrument in a specific way. The correlation between the instrument states chosen by the two observers is determined by the instrument construction*" ([9], p. 102).



Anton Zeilinger later conducted more tests of Bell inequalities. He created entangled pairs of photons by shining a laser on a special crystal, and used random numbers to shift between measurement settings. One experiment used signals from distant galaxies to control the filters and ensure the signals could not affect each other.

©Johan Jamestad/The Royal Swedish Academy of Sciences

Figure 1. Bell's type experiments.

Karl Hess proposed that the derivation of Bell's inequality ignored the mechanism of light signal timing in special relativity in his book "*Einstein was Right*". He believed that the EPR experiment involves correlation, which always implies some important relativity concepts such as "simultaneity": we must measure correlation pairs simultaneously or at a highly correlated time at two different positions, which is exactly one form of instrument correlation mentioned by Jin Guantao.

Karl Hess believed that "*The EPR experiment was dealing with correlations implied always some "simultaneity", a concept that had played a major role in Einstein's relativity theory.*" ([10], p. 47). Therefore, we must measure that correlation pairs in EPR experiments at two different locations at the same time, or at least at a time of high correlation. Everyone knows that time is not a random variable and has a past-present-future time series, but we assume that Bell's λ is a random variable; therefore, λ and time or space-time must be identifiable in mathematics. Time variables should also be regarded as real elements and entered into Bell's inequalities—the Formula (1), but there are not time variables in the Formula (1).

As Karl Hess said, "*If all the equipment stands still in a laboratory, as it usually does, we may replace space-time just by the number i of the actual experiment. Then, time is just regarded as an order parameter, which provides order as we are counting.*" ([10], p. 52). Thus, Karl Hess got an inequality different from Bell's inequality:

$$A_a^i\left(\lambda_i\right)A_b^{i'}\left(\lambda_i\right)+A_a^{i+1}\left(\lambda_{i+1}\right)A_c^{i'+1}\left(\lambda_{i+1}\right)-A_b^{i+2}\left(\lambda_{i+2}\right)A_c^{i'+2}\left(\lambda_{i+2}\right)\leq +3. \tag{2}$$

This inequality is opposite to the popular Bell inequality and it is always correct and does not provide a decisive difference between local hidden variable theory and quantum mechanics. Therefore, experimental verification of Bell's inequality is not sufficient to exclude local realism. This type of experiment involves two experiments in a quasi empty region that perform optical signal timing operations during their respective measurement time periods, which does not meet the requirements of EPR verification. Hess pointed out that a large number of scholars have been involved in the discussions on Bell's inequality ([11], pp. 1574-1575). He believes that when EPR type experiments are explained according to the Bell model, they do not consider all hidden variables and introduce some counterfactual reasoning. The Bell's type's experimental verification always have loopholes, so it can not deny local realism ([12], pp. 713-733).

3. How Does Quantum Gravity Get Involved in Non Locality?

Kip S. Thorne talked about John Wheeler's hope for unification of future physics, and pointed out: "*For general relativity and quantum mechanics, in order to logically integrate the two, it is obvious that one or both of them should be modified. If this fusion is achieved, the ultimate unification of general relativity and quantum mechanics will produce a new set of powerful laws, which physicists call it as quantum gravity.*" [13] In 1916, Einstein found that there are gravitational waves which carry energy and gravity energy should be quantize in order to be compatible with atomic physics. It was Einstein who first proposed the quantum gravity issue: "*It seems that quantum theory will not only correct Maxwell s electromagnetic theory, but will also modify new theories of gravity.*" [14] Moreover, Einstein first suggested that the desirable path for quantum gravity is to correct general relativity to be fit for quantum rules. This has affected most quantum gravity research in the future.

In 1928, Dirac combined the special theory of relativity with quantum mechanics, formed quantum electrodynamics. Not long after, Heisenberg and Pauli claimed in 1929 that "*the quantization of the gravitational field— which is necessary from a physical perspective—can be achieved in a form completely similar to this one without encountering any new difficulties*". ([15], p. 3) However, the recent developments over the past 100 years have surprised us by the difficulty of some great physicists underestimating the problem of quantum gravity. In 1971, shortly after Dutch physicist t'Hooft proved that we can renormalize the Yang-Mills gauge field theory, but the quantum general relativity is non renormalizable, which means that a quantum gravity theory that preserves both quantum rules and general relativity principles may not exist.

Superstring theory originated in the late 1960s from the understanding of the Regge phenomenon of strong interactions. In the mid-1970s, Schwarz *et al.* explained the massless spin 2 particles in closed string theory as gravitons, and since then, string theory has been studied as a unified theory for various interactions. The development of string theory roughly follows the following clues: strong interaction → open string theory → closed string theory → IIA theory, IIB theory, hybrid string theory → M theory → first principles. The basic idea of string theory is that the most fundamental component of the material world is not in the form of particles, known as point like objects, but rather in the form of an oscillating one-dimensional extension with supersymmetry, called a string. Despite achieving some encouraging results, the renormalization problem in quantum field theory has not been completely solved, and the background spacetime of string theory itself and the dynamic mechanism of quantum fields cannot establish a connection similar to the spacetime background of gravitational field generation in general relativity. More seriously, there are too many vacuum solutions for string theory, and there is currently no experimental evidence of supersymmetry and extra dimensions. The enlightening significance of string theory for the study of cosmological problems is very limited.

In the second string revolution, observation had almost no effect. The most perplexing observation in the past 30 years has been the discovery of dark energy. It is like a gravitational source evenly distributed throughout the entire space. Because it is evenly distributed and equal everywhere, nothing falls towards it. Its only effect is on the average velocity of galaxy separation. In 1998, observations of supernovae in distant galaxies showed that the expansion of the universe is accelerating, and the acceleration is best explained by the presence of dark energy. String theory does not predict dark energy and it is difficult to reconcile the detected values. So, the discovery of dark energy heralds a crisis in the field of string theory.

One of the few conclusions we can draw from string theory is that the cosmological constant can only be zero or negative, but the supernova observations in 1998 showed that the universe was expanding and accelerating, meaning that the cosmological constant must be a very small positive number. This is a real crisis because there is clearly a contradiction between the predictions and observations of string theory.

The key breakthrough was in 2003, when scientists at Stanford University finally achieved string theory with a positive cosmological constant. Their starting point is a carefully studied string theory—a flat four-dimensional spacetime with 6-dimensional small geometry at every point. The 6-dimensional curled geometry they chose is the Calabi-Yao space. It was found that if we want a negative or zero cosmological constant, there are infinite different string theories. If we want a theory to have a positive cosmological constant to satisfy observational results, then the number of theories is finite; Current evidence suggests that there are approximately 10^{500}. This means that both observation and experimentation are extremely difficult to confirm or falsify string theory. For explorers who advocate quantum discrete spacetime, another question facing string theory is why flat spacetime does not require quantization, while the bending parts that deviate from flat spacetime must be quantized? In general relativity, flat spacetime and curved spacetime can be transformed through coordinate transformation. We can even argue that changing the definition of geodesics will change the criteria for dividing flat spacetime and curved spacetime.

The starting point of loop quantum gravity is Ashtekar's revolutionary reconstruction of Einstein's theory of general relativity in 1986, which initially assumed that spacetime is composed of discrete elements, and the discreteness of spacetime is the result of combining quantum theory with relativity. Loop quantum gravity originates from the idea of directly describing fields (such as electromagnetic fields) using field lines. The reason why it is called a "loop" is that in the absence of matter, field lines can self close to form a circle. This is the viewpoint of Nielsen, Wilson and Polyakov, and it is precisely this idea that led to string theory in a fixed spacetime background. Loop quantum gravity is the same idea, but developed in a background independent theory as shown in **Figure 2**.

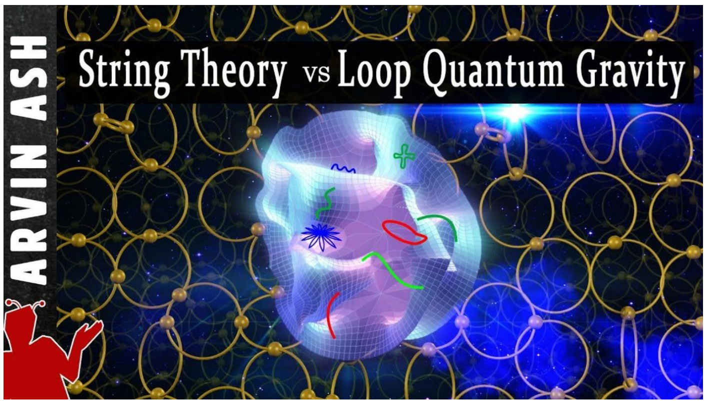


Figure 2. String theory vs loop quantum gravity.

Ashtekar expressed general relativity in the language of gauge fields. In this way, the metric of spacetime becomes something similar to an electromagnetic field. The gravitational field has three sets of field lines, and a correlation network is defined to handle how these three sets of field lines are connected. The two sets of force lines connected and knotted in the same way define the same association, more precisely, the same physical state. This is why we refer to general relativity as correlation theory. The spatial point itself does not exist—the meaning of the point can only be the name we give to the detailed features in the correlation network between the three sets of field force lines. When we process the corresponding field lines using quantum mechanics methods, we must reconstruct quantum field theory and finally obtain loop quantum gravity.

Encouraged by numerous experimental verifications of Bell's inequality, theoretical exploration of loop quantum gravity (LQG) introduced the concepts of quantum non locality, quantum entanglement information, which conflict with the spirit of relativity. The unit of quantum information is the smallest area quantum as quantum bit: "*an area quantum will be a state carrying two equally important bases at the same time. This fundamental characteristic gives the area quantum the property of a superposition state*" ([16], pp. 344-345). The area quantum follows quantum Boolean logic. As Shao Liang, Shao Dan, and Shao Changgui pointed out that "*the possible entanglement between area quanta in quantized space-time, as well as the* '*teleportation*' *of quantum states caused by entanglement associations at a certain moment in the quantized time process* (*i.e. teleportation without time*), *indicate that there may be some kind of entanglement association hidden in the quantum space-time described by the loop quantum force in the sense of quantum mechanics. This entanglement association is very similar to the spin entanglement exhibited by EPR pairs that are already known in quantum mechanics.*" ([16], p. 348).

Along the background independent method of loop quantum gravity, L. Crane put forward relational quantum theory, proposed that "*the right way to apply quantum theory to the universe is not to put the whole universe into one quantum system*" ([17], p. 314), but to regard quantum mechanics as "the description of the boundary relationship between the two subsystems of the universe. Carlo Rovelli further developed this idea. F. Markopoulou and Seth Lloyd attempted to describe the universe as "*a quantum computer with a dynamically generating logic*" ([17], p. 314), they have been leading a movement "*That uses idea from quantum information theory to reconceptualize the universe, leading us to understanding of how basic particles can emerge from quantum space-time.*" ([17], p. 315).

Alan Aspect believed that "*although quantum mechanics can calculate the probabilities of various possible outcomes in experiments with extreme precision, these probabilities only have statistical significance when the same experiment is repeated multiple times. It is this fundamental quantum randomness that prohibits the superluminal propagation of information.*" ([18], p. 3) In Nicolas Gisin's view, "*spooky interactions*" as Einstein said are the remote coordination made by nature but not quantum communication according to quantum rules ([18], p. 44), and there are still detection and locality loopholes in the experimental verification of Bell's inequality ([18], pp. 110-111).

More than 20 years ago, Lee Smolin noticed that some calculations of loop quantum gravity actually contradicted Einstein's special relativity, which led him to abandon loop quantum gravity and reconsider the string theory with many defects. Lee Smolin and others form a variable light velocity cosmology (VSL) thought consistent with the special and general relativity, which is called "gravitational rainbow": "*In the very early universe, when the temperature was very high, the speed of light was, on average, faster than it is now. As you go further back in time and the temperature approaches Planck energy, the speed of light becomes infi-*

nite. It took somewhat longer to show that this led to a version of variable light speed theory that was also in harmony with the principles of general relativity, but we eventually got it, too." ([17], p. 227).

However, in 2022, Hao Li and Bo-Qiong Ma published a paper in Physics Letters B, which calculated the amplitude of the frequency dependent velocity of photons and neutrinos in the universe from the loop quantum gravity model [19]. In 2024, through the exploration and research of astronomers, the variable speed of light model proposed by linearized loop quantum gravity was falsified, and the principle of constant speed of light was once again tested. The various discoveries in cosmology strongly suggest that quantum rules may need to be adjusted or revised at the different levels of material structure. Since the introduction of new quantum rules is required to transition from the daily level spacetime scale to the atomic level spacetime scale, why not consider the transition from the atomic scale to the Planck scale without adjusting the current quantum rules?

4. Has Penrose Solved the Mystery of Quantum Measurements?

Regarding the issue of quantum gravity, Stephen Hawking hoped that the quantization of the gravitational field would help eliminate the singularity problem in general relativity, just as Bohr's stationary orbital model solved the stability problem of atomic structure. However, this idea has been stagnant for a long time due to the difficulty of renormalization in quantized general relativity. Roger Penrose believed that we replace quantization of the gravitational field with gravitation of quantum mechanics, which helps to explain non local phenomena in quantum measurements though the non local energy distribution of the gravitational field. The difference in Weyl curvature between spacetime singularities provides symmetry breaking for all physical processes in the universe in terms of past and future evolutionary directions [20]. However, if there is indeed a disturbance caused by unknown factors that trigger quantum collapse (whether gravitational effects or other factors), then all particles will continuously interact with this disturbance (regardless of whether they are in a superposition state). In theory, we should may detect these interactions like Brownian motions. In 2020, a team in Italy tested a collapse model (Diós-Penrose model) using this germanium detector. After noise reduction, physicists did not see any radiation. In a paper published in August 2022, the results from 2020 were confirmed and strengthened [21].

Most scholars believe that quantum non locality phenomena are unrelated to the non locality of gravitational energy in general relativity. We believe that general relativity involves a global acceleration transformation, which, according to the principle of equivalence, results in a non local energy distribution of the inertial gravitational field. We discuss typically quantum non local phenomena in inertial frames, and the gravitational collapse model of quantum waves involves radiation caused by particle acceleration. However, there is still no experimental evidence to prove the radiation effect of this wave function's gravitational collapse.

There is more than one method to derive Hawking radiation in the classical black hole background by utilizing the renormalization energy momentum tensor $T_{\mu\nu}$ of the quantum field. It is evident that in the calculation of conformal fields in 2D spacetime [22], it has been found that there are both energy momentum contributions along local vacuum polarization and non local contributions from Hawking thermal radiation flow, which can be seen as residual particle flow escaping the event horizon before the formation of the black hole [23]. According to the widely discussed Aharonov-Bohm effect, various physical fields exhibit similar quantum global correlations by affecting quantum phase, whether it is magnetic AB effect, electrical AB effect, or gravitational phase shift effect measured using neutron interferometers [24]. Quantum non locality does not necessarily have a special connection with universal gravity or quantum gravity, such as Penrose's spacetime metric superposition, but rather comes from the overall distribution of any physical field. According to Jin Guantao's analysis of spin electron pair correlations, this type of EPR quantum correlation originates from experimental arrangements that ensure the conservation of momentum and angular momentum. According to Noether's theorem, this ultimately stems from the spacetime symmetry of momentum and angular momentum conservation, that is, the uniformity and isotropy of space. In the discussion of the black hole information paradox, many scholars have not noticed that the spacetime near the black hole does not satisfy the experimental conditions of spatial uniformity and isotropy, that is, it cannot satisfy the EPR correlation. The argument based on some unitary evolution of quantum mechanics to infer the Hawking radiation of quantum bits retained at the black hole's event horizon is incorrect. In the entanglement of particle pairs inside and outside the event horizon of a black hole, quantum information irreversibly disappears, as Hawking pointed out, especially since the black hole is not a closed system as a thermodynamic system, but an open system as described by Prigogine, and the system described based on quantum mechanics unitary evolution is a closed system.

The twistor theory developed rapidly in the first 20 years proposed by Penrose. Many fundamental equations in physics can be rewritten in the form of twistor spaces in surprising and wonderful ways. The twistor theory partially realizes the idea that spacetime can emerge from other structures. The events in our spacetime are just some special surfaces suspended in the twistor space; The geometry of our spacetime can also emerge from the structure of the twistor space. The basic philosophical requirement of the theory of twistor is to transform ordinary physical concepts described by ordinary spacetime concepts into corresponding equivalent (but non local related) descriptions under the twistor theory as shown in **Figure 3** ([17], p. 239).

Lee Smolin believes that there are issues with this scene. The main problem is that the twistor space can only be understood without quantum theory. Although there are significant differences between twistor space and spacetime, it is still a smooth geometric structure. No one knows what twistor space looks like yet. It

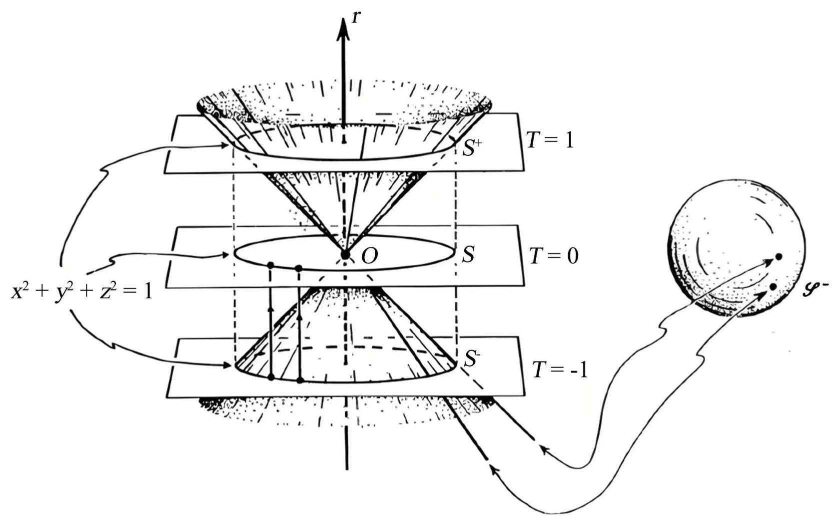


Figure 3. Twistor theory.

is still unknown whether quantum twistor theory is meaningful and whether spacetime can emerge from it. However, the theory of twistor has not yet become a feasible method for quantum gravity, mainly because it cannot accommodate general relativity, and torsion models for nonlinear gravitons are still being attempted. But since 2004, Edward Witten has led a group of physicists to use twistor string frameworks to study gauge and gravitational scattering amplitudes. After the spin enters the twistor form system, a new quantum gravity model emerged that unifies the gauge gravity field and quantum into the twistor geometry framework. Spin provides a quantum physical explanation, achieving the combination of the basic framework of general relativity and the basic framework of the particle standard model. However, Tian-Yu Cao noticed that the general relativity framework with nonlinear gravitational self interactions is based on real spacetime manifolds, while the twistor space is a complex manifold based on spinor analysis and has a richer mathematical structure. The twistor theory regards both gravity and quantum as non fundamental emergent phenomena, and the fundamental position of quantum field theory has also been changed. Although the twistor form system introduced with spin is intrinsic quantum, the twistor operator rooted in the prime agent is still a non local cohomology element [25].

5. Discussion

5.1. Problems in General Relativity

During his lifetime, Lorentz constantly reminded Einstein to redefine the distinction between inertial forces and universal gravitation in general relativity, similar to Newtonian mechanics. The velocity of gravitational waves has been proven through astronomical observations to be the speed of light predicted by general relativity, indicating that the original Newtonian gravity has been localized, similar to an electromagnetic field, with at least two sets of field lines: the Newtonian gravity line equivalent to Coulomb's electric force and the magnetic gravity line equivalent to Ampere's magnetic force line. This is the weak field linear approximation of relativistic gravitational field theory. Its earliest form was obtained by Heaviside in 1893 by imitating Maxwell's equations. In 1905, it was used by Poincaré to calculate that the speed of gravitational waves is the same as light speed. Some scholars published papers questioning how far linear gravity theory can go. From 1966 to 1969, L. Brillouin, J. Carstoiu, and others contributed to the mass of the field source based on the energy of the gravitational field and provided its nonlinear correction as follows [26].

Carstoiu got a set of Maxwell type's gravitation equations:

$$rotF = -\frac{\partial \Omega}{\partial t}, \quad rot\Omega = \frac{1}{c^2}\frac{\partial F}{\partial t} - \frac{G}{c^2}J_g, \quad \nabla F = -GQ_g, \quad \nabla \Omega = 0 \tag{3}$$

In the formula, Q_g is mass density, J_g is gravity flow, Ω is gravity vortex. The mass density Q_g of matter requires an additional correction corresponding to the gravitational energy density: $Q_{extra} = \frac{1}{Gc^2}\frac{\left|F^2\right| + c^2\left|\Omega\right|^2}{8\pi}$, F is common gravity field, Ω is gravitational magnetic field. This non-linear mass correction of Maxwell type's gravitational field results in a gravity energy density formula that is different from electromagnetic field energy density, equivalent to the mass renormalization program in quantum field theory. Due to the absence of the principle of equivalence, there has been no in-depth research on how to handle the energy generated by inertial forces in acceleration systems and how to generate gravitational effects by inertial forces. The most important thing is that Carstoiu's gravity equation uses a geodesic definition different from general relativity, where light and gravitational waves propagate along a straight line at the speed of light in an inertial frame and bend in the same way in an acceleration frame. How light and gravitational waves deflect in a gravitational field and how it differs from the predictions of general relativity need to be studied.

The inertial force field in Newtonian mechanics, should be extended to the third set of force lines of the relativistic gravitational field. In loop quantum gravity, the valence of the spatial quantum is determined by the number of vertices of the spin network, which is exactly 3 ([16], p. 9). We must recognize that the equivalence principle of general relativity strictly holds in a local inertial frame approaching infinitesimal, ignoring the gravitational effects of the experimental object. This makes it almost impossible to handle gravitational two body problems described using a center of mass system, let alone gravitational many body problems. General relativity can currently only handle uniformly rotating single body problems similar to the Kerr metric, as well as ideal fluid problems with uniformity and isotropy as a cosmological model. In general relativity, the approximation of curved spacetime is established by ignoring the gravitational effects of the test object, which assumes the asymmetry between the active gravitational mass (gravitational source) and the passive gravitational mass (test object) from the beginning. This leads to the need to introduce the difference between active gravitational mass, passive gravitational mass, and inertial mass in the approximation of the two body gravity problem.

The energy momentum tensor involves the distribution of force lines in matter density and inertial-gravitational fields. The difference between a single mass gravitational field line and a single charge electric field line is that the gravitational flux must consider the self gravitational effect of gravitational potential energy. The force lines of a two body gravitational field with equal mass are different from the distribution of electric force lines of double equal charges of the like and opposite.

Newton's law of universal gravitation or Poisson's equation presupposes asymptotically flat boundaries, and Newton's acceleration system inevitably changes distant boundaries. The Einstein gravitational field equation includes the Poisson equation, but does not presuppose distant asymptotic flat boundaries. Relativity cosmology defines the boundaries of the universe through cosmological principles, which are not necessarily asymptotically flat, but rather determined by the symmetry of the density of matter in the universe through cosmological principles. The key to distinguishing between inertial force and gravity is the distant asymptotic flat boundary, as well as the difference between gravitational field flux and inertial force flux. General relativity and many double metric theories do not provide a strict distinction between inertial forces and gravity.

Inertial force is equivalent to the overall spacetime deformation after the acceleration transformation of the global spacetime coordinates. It is non local, that is, "*the curved spacetime can theoretically have no Killing vector field*" [27], in which the conservation of momentum and energy cannot be defined, nor can the energy (momentum) density of the inertia-gravity field be defined. Moreover, the contribution of the gravity field to energy is global, requiring integration of the entire space. When we locally equate the gravitational field with the inertial force field as spacetime curvature, the non locality of the energy of the inertial gravitational field is inevitable, just like a circle on a plane and a circle of the same size on a sphere, despite having the same circumference, have different half diameters related to the internal tension (energy distribution). The energy momentum tensor of general relativity requires the exclusion of the contributions of universal gravitation and inertial forces in the Newtonian sense, but must include the contributions of various pressures experienced by objects. In the force analysis of Newtonian systems, pressure often balances gravity and inertial forces.

The equivalence principle includes a constraint condition that introduces the gravitational source as an organizational center of curved spacetime morphology like Aristotle's absolute position (it is not a true absolute position, its space-time position corresponds one-to-one in all coordinate systems through general covariant transformations, this is differential homeomorphism invariance), where the gravitational source that forms a curved spacetime appears to be confined to a certain region of the universe's spacetime, and all test objects of different masses move along the geodesic in this gravitational field. However, when the apple and the moon are located at the same position above the Earth, the acceleration of the Earth-apple system and the acceleration of Earth-moon system relative to their respective centroids are different due to the different gravitational reaction forces acting on the Earth. It is precisely because the equivalence principle is overly idealized in the handling of two body problems that we are forced to introduce controversial conceptual differences such as active mass and passive mass in our calculations. The principle of equivalence eliminates the differential gravity of the Ricci tensor, but cannot eliminate the differential gravity of the Weyl tensor. For various reasons, general relativity spacetime have both significant relative properties and inevitably concealed absoluteness. The relativity and absoluteness of relativistic spacetime are based on local spacetime ranges, while Mach's principle criticizes Newton's view of spacetime by using the action at a distance to discuss the relativity and absoluteness of the entire universe spacetime. If the argument of Newton-Leibniz's spacetime views in relativity philosophy deviates from the principle of contact action among electromagnetic field theory and relativity, it will cause conceptual confusion in the philosophical discussion of spacetime in relativity.

Returning to Lorentz's understanding of general relativity, inertial force is a global effect that occurs instantaneously in an acceleration frame, similar to the space-time structure of various images (composed of past light-cone events) that change instantly upon putting on glasses. Gravity acts through the medium and propagates at the speed of light, similar to the deformation of objects under pressure. According to the mass energy relationship of special relativity, the distribution of gravitational potential energy is similar to that of a thin medium. Thus, gravity has a transmission effect on light. But in general relativity, the gravitational effect is locally equivalent to the spacetime deformation caused by accelerated motion.

Einstein's field equations are equivalent to solving equations to obtain spacetime metric. General covariance is a mathematical transformation of differential homeomorphism, far more than coordinate transformation of reference frames (the transformation of initial boundary conditions restricts the gauge conditions of coordinate transformation). This makes it possible for many solutions of the gravitational field equation to deviate from the boundary constraints of real time and space, becoming a mathematical fiction.

According to the time required for light propagation, it is easy to observe that when Einstein rotates a disk from rest to rotation, an observer at the center of the disk cannot see every position of the rotating disk entering rotation at the same time. Instead, positions closer to the center of the disk enter rotation earlier, and as the distance increases, the circles on the disk from small to large enter rotation in sequence. Many scholars, including Einstein, did not realize that Mach's explanation of Newton's bucket experiment was misleading. The reverse rotation of distant objects seen by observers rotating together at the center of the bucket is just a visual illusion. If distant objects start to rotate simultaneously at a moment, it means that distant objects at different distances should start rotating around a stationary bucket at different past times. The light emitted by distant objects propagates along different distances and reaches the center of the bucket at the same time, and the light from distant objects should exhibit significantly different transverse Doppler effects.

The locality of the equivalence principle not only brings about the non locality of gravitational energy, but also makes it difficult to understand the concepts of gravitational frequency shift and Doppler frequency shift. If there were no cosmic background radiation, a stationary observer at a distance in asymptotic flat spacetime could see the Hawking radiation of the black hole's horizon. When he falls freely towards the black hole without spin approaching the black hole horizon, according to the equivalence principle, the black hole's horizon does not show gravity, and therefore no radiation is observed. In other words, not only is there no Hawking radiation, but there is also no Doppler effect of Hawking radiation near the event horizon of a black hole. But the observer falling freely towards the black hole can observe the Unruh radiation effect in distant vacuum in other directions, especially in the opposite direction of free fall.

In fact, gravity in general relativity not only includes the extension of relativity that combines Newton's gravity and inertial forces through the principle of equivalence, but also includes the gravitational effect caused by the energy variation of pressure and shear force on the work done by an object. The energy momentum tensor of the electromagnetic field inside matter can also have pressure and shear forces, thereby generating gravity [28]. According to Lorentz's suggestion, the various energy-momentum distributions fused by Einstein using the principle of equivalence should be given corresponding relativistic distinctions based on their distinctions in Newtonian mechanics. This is a great mission that Einstein overlooked and did not accomplish. We should not overly rely on the mathematical structure of general relativity and ignore Lorentz's conceptual analysis, but we should also not return to Lorentz's naive concept of a stationary ether ocean to replace Newton's absolute spacetime. Lorentz's stationary ether ocean should indeed be replaced by the overall inertial frame described by Minkowski spacetime, and the apparent inertial force generated in the acceleration frame comes from the overall deformation of Minkowski spacetime, just like a plane curled into a cylinder, cone, and helix, etc., all of which maintain a flat zero curvature. The curvature of spacetime caused by real gravity is always localized near the mass source and decays with distance.

Once we open the closed windows of Einstein's defined local inertial frame, we find that gravity and acceleration produce different frequency shifts for the same radiation. In order to eliminate the apparent non local gravitational energy caused by the global inertial force of the acceleration system, general relativity should be reconstructed with new concepts, mathematical reconstruction, and physical interpretation based on Lorentz's suggestion. That is to say, there is a difference in the initial boundary conditions of the system between the spacetime transformation caused by true gravity and the spacetime transformation caused by accelerated motion. In general relativity, there are four extra degrees of freedom in determining the spacetime coordinate conditions, which precisely arise from the arbitrary combination of inertial forces and true gravity through the principle of equivalence.

Why does Einstein's field equation have four coordinate degrees of freedom related to four Bianchi identities, one being the free choice of the zero point of gravitational potential energy, and the other three being the three spatial degrees of freedom of accelerated motion. Coordinate specifications correspond to the distribution of background inertial gravitational fields or material motion.

In the real world, coordinate transformation is constrained by the same background inertial gravitational field for reference frame transformation. The coordinate transformation of general covariance goes beyond the constraints of the real background spacetime and requires the selection of coordinate conditions that are compatible with the background spacetime in order to obtain the real solution. Although coordinate conditions and boundary conditions are not covariant, the combination of coordinate conditions and boundary conditions for the same system is likely to be generalized covariant. Why are there four Bianchi identities? One answer is that the spacetime coordinates have exactly 4 degrees of freedom in each dimension; Another answer is that each local inertial frame appears to have 6 degrees of freedom in phase space, but the internal boundaries (where inertial forces and gravity cancel each other out) and external boundaries (used to determine that the local inertial frame has no rotation) are predetermined, which reduces 2 degrees of freedom.

Gordon Liu successfully used the de Donder condition to express the real gravitational field as the general gravitational tensor potential in the deformed flat spacetime of the acceleration system, eliminating the arbitrary selection of the four spacetime coordinates in general relativity [29]. But as Fock pointed out: "*In the case of an isolated system of masses there exists a coordinate system*, *namely the harmonic system*, *which is determined uniquely apart from a Lorentz transformation if suitable supplementary conditions are imposed*." [30] And how to express the center of mass system and gravitational potential energy for two body and many body problems are still in the dark chaos. In Gordon Liu's gravity theory of flat spacetime, a flat spacetime absorbing with tensor gravitational potential becomes a curved spacetime, and a curved spacetime desorbing with tensor gravitational potential becomes a flat spacetime. The definitions of gravitational potential energy and experimental particle kinetic energy, including the Lagrangian and Hamiltonian, depend on the metric of spacetime. Einstein's theory treats both inertial and gravitational fields as curved spacetime, while some bi-metric gravity theories treat background natural geometry as inertial forces. The definition of gravitational potential energy should be relative to the asymptotic flat boundary of the field source, while inertial forces in acceleration systems cannot have asymptotic flat boundaries.

The development process of Newton's theory of gravity is: Kepler's Law → inverse square law → gravitational potential → Poisson equation. In the process of exploring the gravitational force of relativity, Einstein once considered using Kepler's third law $T^2/R^3 = k$ to define time and space, but this idea is difficult to coordinate with the idea of defining the length and time of special relativity through the constant speed of light. Reversing the development process of Newtonian gravity in relativity can help us rationally reconstruct general relativity. The derivation of the relativistic gravitational field equation starts from seeking the tensor form of the general covariant Poisson equation. Gordon Liu's research provided a relativistic expression for the gravitational potential energy of a single body. This makes it possible for us to derive a relativistic gravity expression in the deformation flat spacetime of the acceleration system like the inverse square law of universal gravitation in the Newton inertial system. The transformation and synthesis formulas of velocity, acceleration, and force in special relativity urgently require an extension from the inertial frame of Minkowski spacetime to the acceleration frame of deformed flat spacetime as shown in **Figure 4**. In general relativity, we use the principle of equivalence to fuse the global spacetime deformation caused by accelerated motions and the spacetime curvature caused by local gravitational fields into the same spacetime metric representation without distinction.

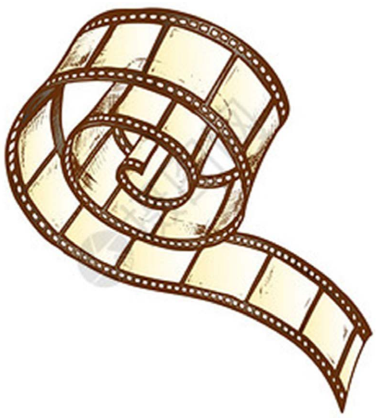


Figure 4. Curled deformation plane.

Discussing gravity in the deformation flat spacetime of an acceleration system means that the definition of geodesics is different from the one in general relativity: light propagates along the shortest line of the deformation flat spacetime in an acceleration system, gravity acts like a medium by changing the speed of light, causing various transmitted light rays to deflect, and light rays in the gravitational field do not propagate along geodesics. In general relativity, the local equivalence of inertial force and gravity automatically satisfies the geodesic equation for the free motion of galaxies in the overall gravitational field of the universe in cosmology. In Newton's approximate cosmological description, the external gravity felt by each galaxy is precisely balanced by the inertial force caused by its own accelerated motion as the universe expands or contracts.

Mach's understanding of inertial mass takes into account the energy momentum distribution of distant objects, thus it is the mechanism of action at a distance generation, which can be seen as the influence of past light cone events on the generation of inertia in general relativity. Lorentz and Poincaré's explanation of electromagnetic mass provides a localized understanding of the origin of inertia. The electromagnetic origin of inertia is endogenous, while the Mach origin of inertia is the contribution of exogenous inertia gravitational potential to inertia.

The general covariation obtained from the principle of equivalence only has local significance, corresponding to local differential homeomorphism pseudo groups, and does not involve transformations of distant boundaries. The global differential homeomorphism group involves the transformation of spacetime boundaries, and the use of the equivalence principle not only means the mixing and exchange of local inertial forces and gravity, but also involves improper mixing and transformation of distant spacetime boundaries. The local equivalence of inertial force and gravity involves the boundary of a closed, non rotating free falling system, but the transformation of distant boundaries is not completely determined by local metric transformations. The spacetime transformation in relativistic cosmology is mixed with local differential homeomorphism pseudo groups and global differential homeomorphism true groups, so spacetime topology can be changed.

There are two physical processes corresponding to general covariation: 1) The reference frame moves arbitrarily relative to the cosmic background radiation, and the background radiation changes due to the motion of the reference frame; 2) The background gravitational fluctuations caused by the motion of binary or multiple stars at the distant boundaries of the universe. General covariation, as a differential homeomorphism transformation, has much greater mathematical possibilities than its corresponding physical processes. General covariation involves the equivalent transformation between the inertial force (with an intrinsic zero curvature) associated with accelerated motion caused by pressure and universal gravitation, and the intrinsic curvature of non-zero gravity caused by geodesic deviation. However, the frequency shifts of background light caused by inertial and gravitational forces are different, manifested in the degrees of freedom of the reference frame coordinates and the degrees of freedom of the background boundary conditions.

René Thom believed that according to Mach's viewpoint, "*the overall structure of space is generated by invariant aggregation regions generated by local events*." ([31], p. 165) According to Einstein's viewpoint, "*Spacetime itself is a fundamental substance*, *a neutral ether*" ([31], p. 159), and "*a local tension of the neutral ether as the basis of various things is manifested*" ([31], p. 165). In Thom's view, quantum mechanics adopted both Mach and Einstein's views on spacetime, but from a philosophical perspective, "Einstein's argument is clearly superior to Mach's argument" ([31], p. 160): Because Mach's viewpoint "*emphasizes the formal and qualitative aspects of local events*, *which is not conducive to separating such local* *events in space*", it has the magical property of action-at-a-distance effects; Einstein's viewpoint "*put forward precise requirements for locality, and therefore seems to be a typical 'scientific' attitude*" ([31], p. 165). Although major practical achievements in science are inseparable from the use of obvious non local effects, "*Einstein used his general theory of relativity to localize gravity; Maxwell used his equations to localize electromagnetic forces*", "*Catastrophe theory is a typical anti magic theory that pushes the principle of locality to its extreme*" ([31], p. 170), and quantum transitions may be the catastrophe and bifurcation mechanisms of unknown harmonic oscillator eigenstates, although they are different from the seven basic mutations of point attractors. If we independently analyze the physical mechanisms and spacetime geometry of gravity theories such as general relativity and non local phenomena, and explore more localized relativistic gravity models and new spacetime geometric models of quantum mechanics as much as possible according to the principle of action through medium in Faraday-Maxwell field theory, we will be closer to Einstein's great goal.

5.2. The Meaning of Quantum Gravity

According to our discussion, among the three sets of force lines in general relativity, the Newtonian effect of universal gravity is equivalent to the electric force line, the special relativistic effect of gravity is equivalent to the magnetic field line, and the general relativistic effect of equivalent gravity in the acceleration system is equivalent to the inertial force line. Most of the flat spacetime gravity theories based on the bi-metric do not follow Lorentz's approach to distinguishing between inertial forces and gravity, but simply treat universal gravity as a deviation from the global Minkowski spacetime metric but not a deformed flat spacetime metric. Therefor the inertial force of deformed spacetime still mixes into the gravitational field, because they believe that Lorentz electrodynamics, which retains the concept of ether, has little value, and Lorentz's criticism of general relativity is a stale concept [32]. However, as proposed by scholars such as Popper [33] and Lee Smolin [34], the cosmic microwave background radiation plays a role similar to that of the ether ocean. For a limited system, distant celestial bodies can be ignored, and microwave background radiation can serve as a boundary condition to distinguish between inertial and acceleration frames. The uniform and isotropic cosmic microwave background is equivalent to the approximate boundary of a finite absolute space. The variation of the microwave background gives the motion state of the observer's reference frame. Based on the Doppler effect of the background radiation, it can be determined whether the observer is in a state of uniform or accelerated motion. The different changes in microwave background radiation can provide an empirical criterion for distinguishing between local inertial frames and local acceleration frames in the Newtonian sense, which is not based on the definition of geodesics in general relativity.

Atoms played a crucial role in the discovery of quantum mechanics. Quantum mechanics is a response to certain properties of atoms that cannot be explained by classical mechanics. The role played by black holes in the search for quantum gravity is very similar to that of atoms in the discovery of quantum mechanics. From the perspective of classical general relativity, black holes possess properties such as singularities, which pose challenges to classical theory and, according to many researchers, signify the collapse of classical general relativity. In addition, black holes are one of the simplest objects that may exist in the universe. The property of black holes raises great expectations for finding a theoretical framework that can accurately describe the quantum mechanical properties of black holes.

When a black hole stabilizes, it only has three independent classical degrees of freedom left: mass, charge, and angular momentum. This has striking similarities with hydrogen atoms: hydrogen atoms also have only three classical degrees of freedom, which are the x, y, and z coordinates of electrons rotating around protons. Of course, quantum field theory studies have shown that in addition to these three classical degrees of freedom, hydrogen atoms also have a large number of quantum mechanical degrees of freedom corresponding to virtual electron positron pairs and photons. However, despite this, the quantum mechanical properties of hydrogen atoms can still be described very accurately by considering only their three classical degrees of freedom in the non relativistic Schrödinger equation. Perhaps black holes have a similar situation: the number of quantum mechanical degrees of freedom in black holes may be enormous, but if we only quantify these three classical degrees of freedom, we may obtain a fairly accurate description of black holes.

Like atoms, black holes also emit so-called black hole radiation or Hawking radiation. For macroscopic black holes, this is mainly composed of neutrinos and photons. One of the main goals of quantum black hole theory is to predict its radiation spectrum. The radiation spectrum also depends on the spectrum of the classical observation of the black hole: when a black hole emits a black hole radiation quantum, it transitions from one eigenstate of the classical observation to another eigenstate [35]. The work of pioneers such as Bekenstein and Hawking suggests that black holes share similarities with atoms in quantum mechanics in certain aspects. This analogy suggests that black hole energy may have a discrete spectrum. Therefore, the quantization of black holes may be the key to quantum gravity theory and has been an important research area in theoretical physics for the past 50 years [36].

The classical collapse model suggests that a self gravity system with sufficient mass will continue to collapse until a singularity is formed. Hawking pointed out that if an event horizon is formed and effective field theory is effective beyond the stretching horizon, black hole radiation is a mixed state for external observers, and free fall observers will not encounter any abnormal situations when crossing the horizon. This leads to the problem of information loss, violating the unitary nature of quantum mechanics. To maintain singularity, two possibilities have been proposed: Hawking radiation is in a pure state or leaves a long-term residual after evaporation. However, if quantum gravity is CPT invariant, the remnants are excluded, leaving only the first possibility. Susskind *et al.* proposed the principle of black hole complementarity, which states that information is emitted both at and through the event horizon, allowing both external and internal observers to see the information, but a single observer cannot confirm both situations simultaneously.

Almheiri *et al.* (AMPS) pointed out that the three hypotheses of black hole complementarity are contradictory. They considered a very large black hole that allows free fall observers to see effectively flat spacetime when crossing the event horizon. From the perspective of an external observer, the pure state of Hawking radiation implies maximum entanglement between late photons and a subset of early radiation. However, when these late photons propagate back to the near horizon region under effective field theory, they must be maximally entangled with the modes within the horizon from the perspective of a free fall observer, which contradicts the strong additivity of entanglement entropy. To avoid paradoxes, AMPS proposes that free fall observers will be burned before crossing the field of view, creating a "firewal" [37]. Various arguments indicate that the unitary evolution of quantum mechanics equations is an overly idealized assumption that does not apply to spacetime and open thermodynamic processes near black holes.

The main points of "The Meaning of Quantum Gravity" regarding the prospects of quantum gravity still have enlightening significance. The book argued that Einstein's strong equivalence principle requires the dynamic coupling of spacetime and matter, while traditional quantum field theory relies on a fixed spacetime background for perturbation expansion, and the methodological frameworks of the two are irreconcilable opposites. Directly quantizing general relativity will lead to infinite curvature divergence and black hole singularity problems. The author supports Einstein's argument that the geometric essence of spacetime (defined by the strong equivalence principle) cannot be transformed into discrete quantum objects through traditional quantization methods, and therefore proposes that general relativity may be essentially a "non quantized" theory.

The local observational definition of classical general relativity, such as geodesics, needs to be replaced by algebraic relationships of quantum reference frames to reconcile the differences between microscopic quantum effects and macroscopic gravitational phenomena. The introduction of the "graviton" as a quantum gravitational carrier has been criticized as failing to address the core contradiction—the essential conflict between space-time discretization and dynamic geometry, and is only a quantized simulation of classical gravitational waves [38].

String theorists who advocate background dependent paths argue that the book's rejection of the feasibility of quantization in general relativity is too radical. String theory has made progress in mathematical unity based on a fixed spatiotemporal background framework (such as the theoretical construction of supersymmetry and extra dimensions), while the background independent path proposed in the book may overlook the potential advantages of string theory.

6. Conclusions

Our new approach to exploring quantum gravity is: 1) Introducing correlated parameters of quantum measurement instruments related to the timing of light signals, and expressing quantum mechanics as locally as possible. Zhao Zheng discovered through his research on the thermodynamics of black holes that the calibration time of optical signals can only satisfy the transitivity of simultaneity in a coordinate system where the time axis is orthogonal to the three spatial axes. This requires a special coordinate requirement for defining temperature, greatly increasing the difficulty of developing thermodynamics and statistical mechanics in general relativity, and making the combination of general relativity and quantum mechanics almost impossible [39]. 2) Clearly define the geodesic in an acceleration system without gravity and provide the deformation flatness spacetime metric for the acceleration system. We define the path that light takes in a vacuum that ignores the gravitational force of an object as a geodesic. Gravitational potential energy in a vacuum is equivalent to a medium with a dielectric constant and magnetic permeability different from that of a vacuum [40]. The bending of light in a gravitational field is no longer seen as a geodesic effect in curved spacetime, but as a refraction effect caused by changes in the distribution of energy density in the gravitational field. This deviates from the geodesic defined in the inertial or acceleration frame according to the requirement of the disappearance of the gravitational field. 3) Without introducing Einstein's geodesic definition, seek a relativistic gravitational potential energy expression for multi-body gravitational sources in a global inertial frame, and attempt to express the quantum mechanical operator corresponding to this gravitational potential energy. 4) By using the transformation relationship between the geodesic of the inertial frame and the geodesic of the acceleration frame without universal gravitation, the relativistic gravitational potential energy expression of the multi-body gravitational source in the acceleration frame is given. At present, Liu Gordon has provided a generalized tensor potential for the single body gravitational field, but it requires arduous exploration to provide the relativistic gravitational potential energy for two or even many bodies. 5) Seeking the asymptotic correspondence mapping between the deformation flat spacetime of the acceleration system in this new gravity theory and the curved spacetime of general relativity, it is shown that general relativity is just a reasonable approximation of the new gravity theory that ignores the gravitational reaction force of the experimental object. When constructing curved spacetime based on the principle of equivalence in GR, we neglected the gravitational reaction of the experimental object on the gravitational source, which may be one of the reasons for the non conservation of energy in relativistic cosmology, and also a root cause of the forced introduction of active gravitational mass and passive gravitational mass when approximating the gravitational two body problem. 6) The space-time mapping between the new theory of gravity and general relativity is similar to a stereographic projection, and may not necessarily be a one-to-one correspondence of space-time point mapping as shown in **Figure 5**. The general covariance of general relativity is not a transformation between the new theory of gravity and general relativity, because the spacetime transformation of the new theory of gravity is a metric transformation between the Minkowski spacetime of the inertial frame and the deformed flat spacetime of the acceleration frame, but not a space time transformation between any two reference frames located in the same gravitational source as in GR.

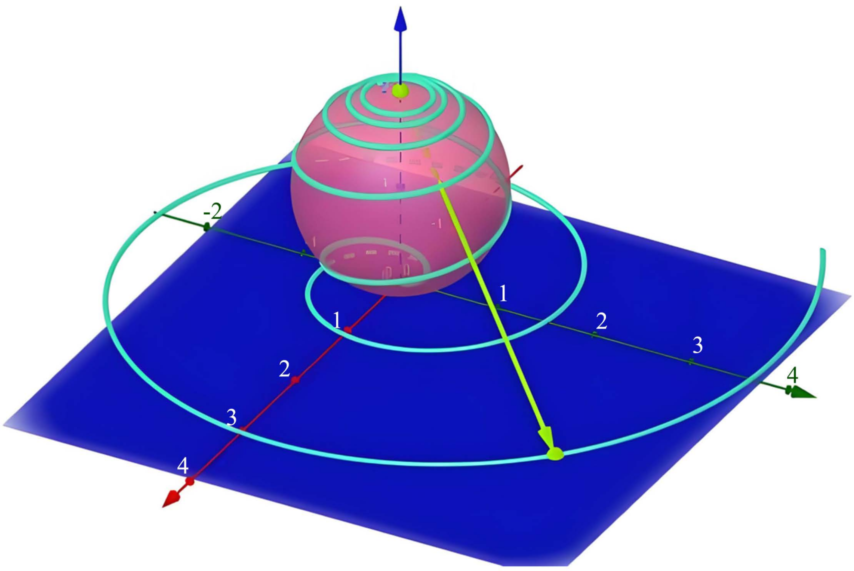


Figure 5. Stereographic projection.

At present, this is a theoretical framework based on conceptual analysis, and a mathematical model has not yet been established. The description of curved spacetime in general relativity is incomplete in terms of ignoring the gravitational reactions of experimental objects, as it does not fully incorporate the reasonable connotations of Newton's theory of gravity. In terms of its deviation from the description of Faraday force lines in electromagnetic fields, GR is also incomplete in implementing the electromagnetic program of physics. Lorenz's criticism of general relativity, like Einstein's criticism of quantum mechanics, although controversial, guides the future path of physics because their physical intuitions are partially correct. However, due to deviating from mainstream trends and the lack of rigorous mathematical expressions in the conceptual analysis used, it is difficult for observations and experiments to support their criticism. Einstein criticized quantum mechanics by mistakenly adhering to deterministic descriptions, but it is precisely because of quantum randomness that the possibility of microscopic non local effects being used to transmit information faster than light is ruled out. Lorentz mistakenly insisted on defining absolute space using the concept of stationary ether as the standard for distinguishing between the global inertial frame and the global acceleration frame, without realizing that his introduction of the concept of local time made the distinction between inertial and acceleration frames in relativity localized and dynamic. Einstein's special definition of light propagating along geodesics in a vacuum of any reference frame allowed general relativity to simply describe the free motion of celestial bodies in a gravitational field as geodesic motion in cosmology. However, it also made it particularly difficult to use general relativity to deal with two body and many body gravity problems, as the initial boundary conditions of many body gravity problems do not have the boundary of exact symmetry given by cosmological principles.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Einstein, A., Podolsky, B. and Rosen, N. (1935) Can Quantum-Mechanical Description of Physical Reality Be Considered Complete? *Physical Review*, **47**, 777-780. https://doi.org/10.1103/physrev.47.777

[2] Jammer, M. (2014) Philosophy of Quantum Mechanics. Business Press.

[3] Zhang, Y.D. (2012) Roots of Quantum Wisdom. Tsinghua University Press.

[4] Penrose, R. (1994) Emperor's New Brain. Hunan Science and Technology Publishing House.

[5] Penrose, R. and Ishanm, C.J. (1986) Quantum Concepts in Space and Time. Oxford University Press, 293-301.

[6] Fritzsch, H. (2008) Sir Irren, Einstein! Piper Verlag.

[7] Scully, M.O., Aharonov, Y. and Englert, B. (1999) On the Locality and Reality of Einstein-Podolsky-Rosen Correlations. *Mysteries, Puzzles, and Paradoxes in Quantum Mechanics*, **461**, 47-68. https://doi.org/10.1063/1.57850

[8] Gell-Mann, M. (1997) Quark and Puma. Hunan Science and Technology Press.

[9] Jin, G.T. (2005) My Philosophy Study. New Star Publisher.

[10] Hess, K. (2015) Einstein Was Right! Pan Stanford Publishing.

[11] Hess, K. (2018) Bell's Theorem and Instantaneous Influences at a Distance. *Journal of Modern Physics*, **9**, 1573-1590. https://doi.org/10.4236/jmp.2018.98099

[12] De Raedt, H., Michielsen, K. and Hess, K. (2017) The Photon Identification Loophole in EPRB Experiments: Computer Models with Single-Wing Selection. *Open Physics*, **15**, 713-733. https://doi.org/10.1515/phys-2017-0085

[13] Thorne, K.S. (2000) Black Hole and Time Curve. Hunan Science and Technology Publishing House.

[14] Albert, E. (1916) Approximate Integration of the Field Equation of Gravitation. In: *Sitzungsberichte der Preussische Akadamie der Wissenchaften*, Nabu Press, 688-696.

[15] Heisenberg, W. and Pauli, W. (2019) Zur Quantemdynamik der Wellenfelder. *Zeitschrift für Physik*, **56**, 1-61.

[16] Shao, L., Shao, D. and Shao, C.G. (2011) Quantum Theory of Space and Time. Science Press.

[17] Smolin, L. (2007) The Trouble with Physics. Houghton Mifflin Company.

[18] Gisin, N. (2016) L'Impensable Hasard. Shanghai Science and Technology Press.

[19] Li, H. and Ma, B. (2023) Speed Variations of Cosmic Photons and Neutrinos from Loop Quantum Gravity. *Physics Letters B*, **836**, Article 137613. https://doi.org/10.1016/j.physletb.2022.137613

[20] Hawking, S.W. and Penrose, R. (1996) The Nature of Space and Time. *Scientific American*, **275**, 60-65. https://doi.org/10.1038/scientificamerican0796-60

[21] Donadi, S., Piscicchia, K., Curceanu, C., Diósi, L., Laubenstein, M. and Bassi, A. (2020) Underground Test of Gravity-Related Wave Function Collapse. *Nature Physics*, **17**, 74-78. https://doi.org/10.1038/s41567-020-1008-4

[22] Frolov, V.P. and Vilkovisky, G.A. (1979) Quantization of Fields and Gravitational Condensates. *Proceeding of 2nd Marcel Grossmann Meeting*, Trieste, 5-11 July 1979, 5-11.

[23] Mukhanov, V.F. and Winitzki, S. (2010) Introduction to Quantum Effects in Gravity. Cambridge University Press & Beijing World Publishing Corporation.

[24] Zeng, J.Y. (2000) Quantum Mechanics: Volume II. 3rd Edition, Science Press.

[25] Tian, Y.C. (2025) Twistor, Cohomology, Foundation of Physics. *International Journal of Modern Physics A*, **2025**, Article 2530002.

[26] Brillouin, L. (1970) Relativity Reexamined. Academic Press.

[27] Liang, C.B. (2001) Introduction to Differential Geometry and General Relativity (Volume 2). Beijing Normal University Press, 383-385.

[28] Shen, X.Y. (2022) Decoding Gravity. Chemical Industry Press, 279-283.

[29] Liu, G. (2013) Riemannian Space-Time, De Donder Conditions and Gravitational Field in Flat Space-Time. *International Journal of Astronomy and Astrophysics*, **3**, 8-19. https://doi.org/10.4236/ijaa.2013.31002

[30] Fock, V. (1959) The Theory of Space-Time and Gravitation. Pergamon Press, 350.

[31] Thom, R. (1989) Mathematical Models of Morphogenesis. Shanghai Translation Publishing House.

[32] Rosen, N. (1973) A Bi-Metric Theory of Gravitation. *General Relativity and Gravitation*, **4**, 435-447. https://doi.org/10.1007/bf01215403

[33] Popper, K. (1982) Quantum Theory and the Schism in Physics, Introductory Comments. Unwin Hyman, 24-26.

[34] Smolin, L. (2013) Time Reborn. Spin Networks Ltd.

[35] Mäkelä, J. (2002) Black Holes as Atoms. *Foundations of Physics*, **32**, 1809-1849. https://doi.org/10.1023/a:1022362515809

[36] Corda, C. (2023) Schrödinger and Klein-Gordon Theories of Black Holes from the Quantization of the Oppenheimer and Snyder Gravitational Collapse. *Communications in Theoretical Physics*, **75**, Article 095405. https://doi.org/10.1088/1572-9494/ace4b2

[37] Vaz, C. (2014) Blackholes as Gravitational Atom. *International Journal of Modern Physics D: Gravitation, Astrophysics and Cosmology*, **23**, Article 1441002.

[38] von Borzeszkowski, H.H. and Treder, H. (1988) The Meaning of Quantum Gravity. D. Reidel.

[39] Zhao, Z. (1991) The Transitivity of Thermal Equilibrium Is Equivalent to the Transitivity of Clock Speed Synchronization. *Science in China* (*Series A*), **3**, 285-289.

[40] Jia, S.Q. (2018) Electromagnetic Waves in Curved Spacetime. Northeastern University Press, 186-189.